Q1. **Table 1** shows information about different light bulbs.

The bulbs all have the same brightness.

Table 1

Type of bulb	Input power in watts	Efficiency
Halogen	40	0.15
Compact fluorescent (CFL)	14	0.42
LED	7	0.85

(a) (i) Calculate the useful power output of the CFL bulb.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

Useful power output = ... watts

(2)

(ii) Use your answer to part **(i)** to calculate the waste energy produced each second by a CFL bulb.

.....

Waste energy per second = ... joules

(1)

(b) (i) A growth cabinet is used to investigate the effect of light on the rate of growth of plants.

The figure below shows a growth cabinet.

In the cabinet the factors that affect growth can be controlled.

A cooler unit is used to keep the temperature in the cabinet constant. The cooler unit is programmed to operate when the temperature rises above 20 °C.

The growth cabinet is lit using 50 halogen bulbs.

Changing from using halogen bulbs to LED bulbs would reduce the cost of running the growth cabinet.

Explain why.

.....

.....

.....

.....

.....

.....

(4)

(ii) A scientist measured the rate of growth of plants for different intensities of light.

What type of graph should be drawn to present the results?

.....

Give a reason for your answer.

.....

.....

(1)

(c) **Table 2** gives further information about both a halogen bulb and a LED bulb.

Table 2

Type of bulb	Cost to buy	Lifetime in hours	Operating cost over the lifetime of one bulb
Halogen	£1.50	2 000	£16.00
LED	£30.00	48 000	£67.20

A householder needs to replace a broken halogen light bulb.

Compare the cost efficiency of buying and using halogen bulbs rather than a LED bulb over a time span of 48 000 hours of use.

Your comparison must include calculations.

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(4)
(Total 12 marks)

Q2. (a) Electromagnetic waves form a continuous spectrum with a range of wavelengths.

What is the approximate range of wavelengths of electromagnetic waves?

Tick (✓) **one** box.

10^{-15} metres to 10^{4} metres ☐

10^{-4} metres to 10^{15} metres ☐

10^{-6} metres to 10^{6} metres ☐

(1)

(b) Infrared waves and microwaves are used for communications.

(i) Give **one** example of infrared waves being used for communication.

.....

.....

(1)

(ii) A mobile phone network uses microwaves to transmit signals through the air. The microwaves have a frequency of 1.8×10^9 Hz and travel at a speed of 3.0×10^8 m/s.

Calculate the wavelength of the microwaves.

Use the correct equation from the Physics Equations Sheet.

Give your answer to **two** significant figures.

.....

.....

.....

Wavelength = ... m

(3)

(c) Some scientists suggest there is a possible link between using a mobile phone and male fertility.

The results of their study are given in the table.

Mobile phone use in hours per day	**Sperm count in millions of sperm cells per cm^3 of semen**
0	86
less than 2	69
2 – 4	59
more than 4	50

The results show a negative correlation: the more hours a mobile phone is used each day, the lower the sperm count. However, the results do **not** necessarily mean using a mobile phone causes the reduced sperm count.

Suggest **one** reason why.

.....

.....

(1)

(Total 6 marks)

Q3. (a) Water waves are transverse waves. Sound waves are longitudinal waves.

(i) Explain the difference between a transverse wave and a longitudinal wave.

You may include labelled diagrams in your answer.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(3)

(ii) Name **one** type of wave that may be either transverse or longitudinal.

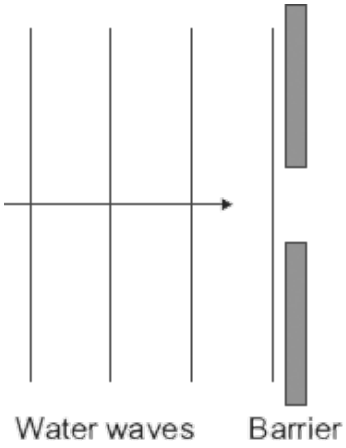
.....

(1)

(b) The diagram shows water waves in a ripple tank moving towards a gap in a barrier.

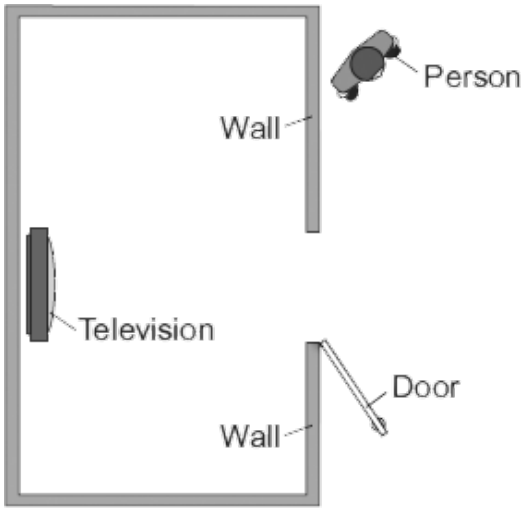
The water waves diffract as they pass through the gap.

Complete the diagram to show the diffracted water waves.



(1)

(c) A television is switched on inside a room. A person outside the room can hear the television, but only when the door is open.



When the door is open, the person can hear the sound but cannot see the television.

Explain why.

.....

.....

.....

.....

(2)

(Total 7 marks)

Q4. (a) Microwaves are one type of electromagnetic wave.

(i) Which type of electromagnetic wave has a lower frequency than microwaves?

.....

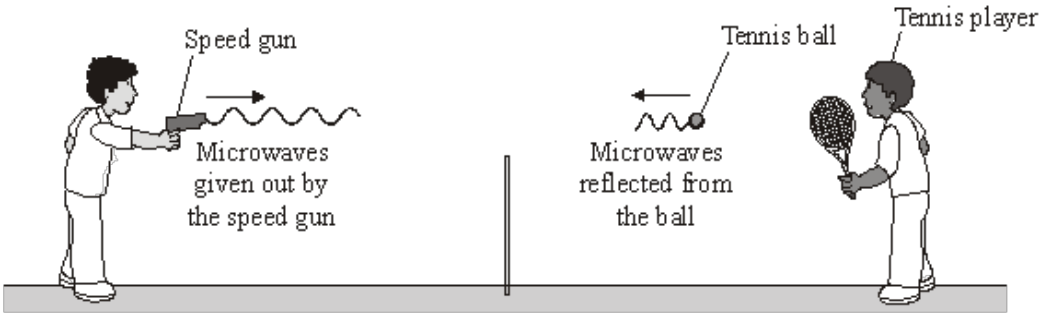
(1)

(ii) What do all types of electromagnetic wave transfer from one place to another?

.....

(1)

(b) The picture shows a tennis coach using a speed gun to measure how fast the player serves the ball.



(i) The microwaves transmitted by the speed gun have a frequency of 24 000 000 000 Hz and travel through the air at 300 000 000 m/s.

Use the equation in the box to calculate the wavelength of the microwaves emitted from the speed gun.

wave speed = frequency × wavelength

Show clearly how you work out your answer.

.....

.....

Wavelength = ... m

(2)

(ii) Some of the microwaves transmitted by the speed gun are absorbed by the ball.

What effect will the absorbed microwaves have on the ball?

.....

.....

(1)

(iii) Some of the microwaves transmitted by the speed gun are reflected from the moving ball back towards the speed gun.

Describe how the wavelength and frequency of the microwaves change as they are reflected from the moving ball.

.....

.....

.....

.....

(2)

(Total 7 marks)

Q5. (a) A student listens to the sound waves produced by a car siren. When the car is stationary, the student hears a constant frequency sound.

Describe how the wavelength and frequency of the sound waves heard by the student change when the car is driven away from the student.

.....

.....

.....

.....

(2)

(b) Satellites fitted with various telescopes orbit the Earth. These telescopes detect different types of electromagnetic radiation.

Why are telescopes that detect different types of electromagnetic waves used to observe the Universe?

.....

.....

(1)

(c) In 2005 a space telescope detected a star that exploded 13 billion years ago. The light from the star shows the biggest *red-shift* ever measured.

(i) What is *red-shift*?

.....

.....

(1)

(ii) What does the measurement of its red-shift tell scientists about this star?

.....

.....

(1)

(d) Red-shift provides evidence for the ‘big bang’ theory.

(i) Describe the ‘big bang’ theory.

.....

.....

.....

.....

(2)

(ii) Suggest what scientists should do if new evidence were found that did not support the 'big bang' theory.

.....

.....

.....

(1)

(Total 8 marks)

Q6. (a) The student is using a microphone connected to a cathode ray oscilloscope (CRO).

The CRO displays the sound waves as waves on its screen. What does the microphone do?

.....

.....

.....

(2)

(b) The amplitude, the frequency and the wavelength of a sound wave can each be either increased or decreased.

(i) What change, or changes, would make the sound quieter?

.....

(1)

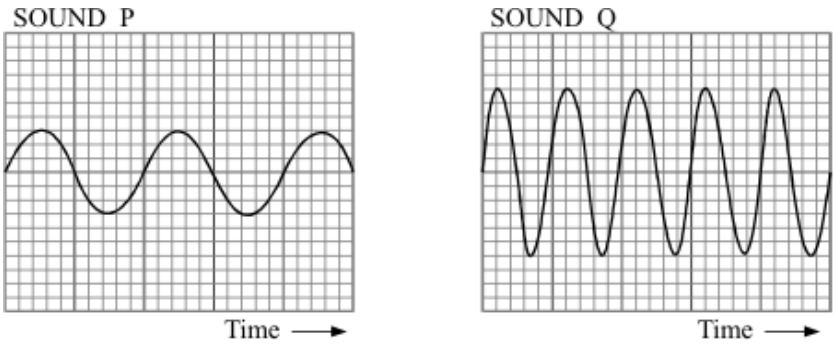
(ii) What change, or changes, would make the sound higher in pitch?

.....

(1)

(Total 4 marks)

Q7. The diagram shows the oscilloscope traces of two different sounds P and Q. The oscilloscope setting is exactly the same in both cases.



P and Q **sound** different.
Write down **two** differences in the way they sound.
Explain your answers as fully as you can.

1 .....

.....

.....

2 .....

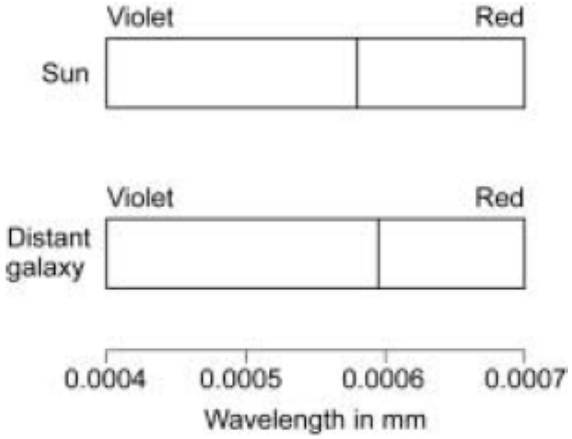
.....

.....

(Total 5 marks)

Q8. The visible part of the electromagnetic spectrum from a star includes a dark line. This line is at a specific wavelength.

The diagram shows the position of the dark line in the spectrum from the Sun and in the spectrum from a distant galaxy.



(a) Explain how the spectrum ‘shift’ of the dark line supports the theory that the Universe began from a very small initial point.

.....

.....

.....

.....

.....

.....

(3)

(b) Name **one** other piece of evidence that supports the theory that the Universe began from a very small initial point.

.....

(1)

(Total 4 marks)

M1. (a) (i) 5.88 (watts)

*an answer of 5.9 scores **2** marks*

*allow **1** mark for correct substitution ie*

$0.42 = \frac{\text{power out}}{14}$

*allow **1** mark for an answer of 0.0588 or 0.059*

2

(ii) 8.12

allow 14 – their (a)(i) correctly calculated

1

(b) (i) input power / energy would be (much) less (reducing cost of running)

accept the converse

electricity is insufficient

1

(also) produce less waste energy / power

accept 'heat' for waste energy

1

(as the waste energy / power) increases temperature of the cabinet

1

so cooler on for less time

1

(ii) line graph

need to get both parts correct

accept scattergram or scatter graph

both variables are continuous

allow the data is continuous

1

(c) number of bulbs used-halogen=24 (LED=1)

1

total cost of LED = £30 + £67.20 = £97.20

accept a comparison of buying costs of halogen £36 and LED £30

1

total cost of halogen= 24 x £1.50 + 24 x £16.00 = £420

or

buying cost of halogen is £36 **and** operating cost is £384

accept a comparison of operating costs of halogen £384 and LED £67.20

*allow for **3** marks the difference in total cost is £322.80 if the number 24 has not been credited*

1

statement based on correct calculations that overall LED is cheaper

*must be **both** buying **and** operating costs*

an alternative way of answering is in terms of cost per hour:

buying cost per hour for LED $\left(\frac{£30.00}{48000}\right)$ = 0.0625p/£0.000625

buying cost per hour for halogen = $\left(\frac{£1.50}{2000}\right)$ = 0.075p/£0.00075

*a calculation of both buying costs scores **1** mark*

operating cost per hour for LED = $\left(\frac{£67.20}{48000}\right)$ = 0.14p/£0.0014

operating cost per hour for halogen= $\left(\frac{£16.00}{2000}\right)$ = 0.8p/£0.008

*a calculation of both operating costs scores **1** mark*

all calculations show a correct unit

***all** units correct scores **1** mark*

statement based on correct calculations of **both** buying **and** operating costs, that overall LED is cheaper

*correct statement scores **1** mark*

1

[12]

M2. (a) 10^{-15} metres to 10^{4} metres

1

(b) (i) any **one** from:

- (TV / video / DVD) remote controls

  mobile phones is insufficient
- (short range) data transmission

  accept specific example, eg linking computer peripherals
- optical fibre (signals)

  *do **not** accept Bluetooth*

1

(ii) 0.17

*an answer 17 cm gains **3** marks*

*an answer given to more than 2 significant figures that rounds to 0.17 gains **2** marks*

*allow **1** mark for correct substitution, ie $3 \times 10^{8} = 1.8 \times 10^{9} \times \lambda$*

3

(c) (maybe) other factors involved

accept a named 'sensible' factor, eg higher stress / sedentary lifestyle / overweight / smoking more / diet / hot office / age

not testing enough people is insufficient

unreliable data is insufficient

1

[6]

M3. (a) (i) the oscillation / vibration (causing the wave)

a movement causes the wave is insufficient

1

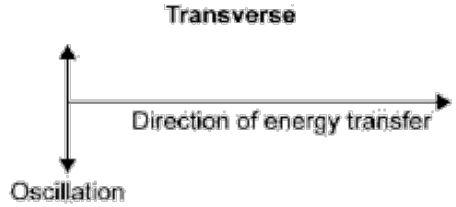
for a transverse wave is perpendicular to the direction of energy transfer

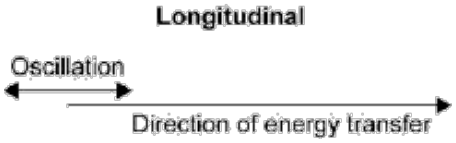
*answers given in terms of direction of wave travel and not energy transfer for both types of wave, score **1** mark for these **two** mark points*

1

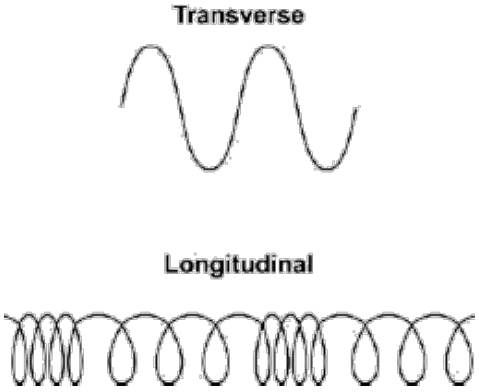
and for a longitudinal wave is parallel to the direction of energy transfer

the marks may be scored by the drawing of two correctly labelled diagrams ie





two labelled diagrams showing the general form of a transverse and longitudinal wave gain 1 mark if no other mark has been awarded eg



1

(ii) mechanical wave

accept specific examples, eg waves on a spring / slinky / seismic / earthquake waves

accept water waves

*do **not** accept shock waves*

1

(b) semicircular waves drawn

judged by eye

do not need to be full semicircles

ignore any rays

1

(c) sound (waves) will <u>diffract</u> (towards the person)

1

or

light (waves) do not diffract (towards the person)

(because) width of door way similar to / less than wavelength of sound (waves)

or

(because) width of doorway much greater than wavelength of light (waves)

*a general statement that waves (only) <u>diffract</u> when the width of a gap is similar to the wavelength of the waves can be awarded **1** mark*

1

[7]

M4. (a) (i) radio(waves)

1

(ii) energy

correct answer only

1

(b) (i) 0.0125 (m)

*allow **1** mark for correct transformation <u>and</u> substitution*

2

(ii) make it hot(ter)

*do **not** accept cook it*
accept (air) particles inside ball will move faster
accept water in the ball gets hotter

1

(iii) wavelength decreases

ignore reference to speed

1

frequency increases

1

[7]

M5. (a) wavelength increases

accept the crests are further apart

ignore waves are further apart

1

frequency decreases

accept pitch decreases

ignore references to amplitude

1

(b) stars / galaxies / sources emit all / different types of electromagnetic waves / radiation

accept two or more named electromagnetic waves

accept answers in terms of frequencies / wavelengths

1

(c) (i) wavelength (of light) increases

accept frequency decreases

or

light moves to red end of spectrum

*accept redder but do **not** accept red alone*

1

(ii) it is the star (detected) <u>furthest</u> from the Earth

accept galaxy for stars

or

it is moving <u>away</u> the fast<u>est</u>

ignore reference to universe expanding

1

(d) (i) all matter compressed to / starts at / comes from a single point

*do **not** accept increasing gravitational pull*

accept everything / the universe for all matter

1

(massive) explosion sends matter outwards

accept explosion causes universe to expand

*ignore explosion creates the universe **or** further reference to star / Earth formation*

1

(ii) check validity / reliability of the evidence

or

change the theory to match the new evidence

accept comparison of new and old evidence

1

[8]

M6. (a) changes the sound wave(s)

to a varying **or** changing (electric) potential difference **or** p.d. **or** voltage **or** current **or** to an irregular alternating current or a.c. **or** transfers sound energy to electrical energy (1) mark is vibrations **or** pulses **or** of sound **or** in air become electrical waves

*do not credit just 'to electricity' **or** 'to a.c'*

2

(b) (i) decrease **or** reduce the amplitude

accept less amplitude nothing else added

1

(ii) increase the frequency **or** decrease wavelength

accept higher frequency nothing else added

1

[4]

M7. • Q is louder

• Q is higher (pitch/note but <u>not</u> frequency)

[if loudness and pitch both mentioned but direction wrong / absent credit 1 mark]

• louder because bigger amplitude/height

• higher pitch because higher frequency/shorter wavelength/waves closer together

• factor of 2 mentioned w.r.t either

(NB converse answer for P)

each • for 1 mark

[5]

M8. (a) the observed wavelength of the dark line from the distant galaxy has increased

1

therefore the distant galaxy must be moving away from the Earth

1

suggesting the Universe is expanding outwards from a small initial point

1

(b) existence of cosmic microwave background radiation

accept existence of CMBR

1

[4]